REMARKS

In the Office Action mailed on March 31, 2008, claims 1, 2, 5-24 and 51 were rejected under 35 U.S.C. §103(a) as unpatentable over Hampden-Smith et al. ("the '434 publication"). Claims three and four were rejected as obvious over the '434 publication in view of Pomeroy et al. ("the '487 patent"). These rejections are traversed for the reasons set forth below.

A. SUMMARY OF ARGUMENTS

It is submitted that the obviousness rejection of claim 1 is improper for at least the following reasons:

- The cited references fail to teach a formic acid fuel used with a Pd nanoparticle catalyst
- The cited references fail to offer any teaching, suggestion or motivation to combine a Pd nanoparticle catalyst with a formic acid fuel
- The claimed combination achieves unexpected results

These reasons are discussed below.

B. NO PRIMA FACIE CASE OF OBVIOUSNESS HAS BEEN ESTABLISHED

With regards to the obviousness rejection of claims 1, 2, 5-24 and 51 over the '434 publication, it is submitted that no prima facie case of obviousness has been established. Claim 1 is independent, and all other claims subject to this rejection depend from claim 1. Claim 1 requires (among other elements) a fuel cell having a formic acid fuel together with an anode having an electrocatalyst comprising palladium nanoparticles. The office action admits that the '434 publication fails to teach this combination, but alleges that the '434 publication teaches a membrane electrode assembly (MEA) having an electrocatalyst comprised of palladium nanoparticles used with a methanol fuel, that the background of the invention section of the '434 publication discloses that formic acid fuel solutions are known,

and that it would have been obvious to combine these teachings. It is submitted that this is an improper rejection.

OBVIOUSNESS LEGAL STANDARD

The MPEP states that a prima facie case of obviousness requires, among other things, objective evidence which establishes (under a preponderance of the evidence standard), a teaching to modify the prior art reference components to construct a device substantially equivalent to that claimed. This generally encompasses two sub-steps: (1) identifying objective evidence teaching how to modify the prior art components; and (2) identifying objective evidence teaching how to combine the modified individual components. MPEP §§2141, 2143.

The Examiner must set forth a rationale, supported by objective evidence (under a preponderance of the evidence standard), that the prior art at the time of invention provided a teaching to modify and/or combine the prior art reference components to achieve the claim at issue. Id. The preferable evidence is an express teaching to modify/combine within the properly defined sources of prior art. In the absence of such express teaching, an Examiner may attempt to establish a rationale to support a finding of such teaching reasoned from, or based upon, express teachings taken from the prior art. MPEP § 2144; In re Dembiczak, 50 U.S.P.Q. 2d 1614 (Fed. Cir. 1999).

This has been referred to as the "teaching/suggestion/motivation test" (TSM). Although a rigid application of TSM was rejected in KSR Int'l. Co. v. Teleflex, Inc., 82 USPQ2d 1385 (2007), the test was not discarded. The Court simply required consideration of the general knowledge of those skilled in the art and other factors, using a common sense approach to obviousness, but also warned against overly broad findings of obviousness:

> ...a patent composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art. ... (I)t can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does. This is so because inventions in most, if not all, instances rely upon building blocks long since uncovered, and claimed

> discoveries almost of necessity will be combinations of what, in some sense, is already known.

Id., at 1741. The MPEP also warns against overly broad findings of obviousness based on the impermissible use of hindsight. The MPEP has set forth at least two rules that ensure against such rejections. The first is that it is impermissible to use hindsight gained from considering the application in an obviousness rejection:

> ... the Examiner must step backward in time and into the shoes worn by the hypothetical "person of ordinary skill in the art" when the invention was ... (made) ... Knowledge of an Applicant's disclosure must be put aside in reaching this determination, ... The tendency to resort to "hindsight" based upon an Applicant's disclosure is often difficult to avoid due to the very nature of the examination process.

MPEP §2142. Thus, if the only objective evidence of such teaching to modify and/or combine is found in applicant's disclosure, no evidence of such teaching exists.

The second rule requires that an alleged advantage or beneficial result that would have been produced by a modification and/or combination of the prior art reference components must be found in objectively verifiable teachings of the prior art. MPEP §2144. Thus, to avoid the use of impermissible hindsight, these MPEP rules make clear that absent objective evidence (sufficient to satisfy the preponderance of the evidence standard), no teaching of such modification and/or combination exists.

In consideration of the above, it is submitted that the obviousness rejections of the claims is contrary to the rules set forth by the courts and the MPEP. The structure of claim 1 achieves unexpected advantages over the prior art and there has been no objective evidence put forth suggesting that one considering the '434 publication would have any expectation of achieving these or would be led to trying the claimed combination of a formic acid fuel solution with palladium nanoparticle catalyst. It is further submitted that the obviousness rejection of claim 1 over the '434 publication can only be made through the impermissible use of hindsight gained after considering the present application.

THE FUEL CELL OF CLAIM 1 ACHIEVES UNPREDICTABLE AND UNEXPECTED ADVANTAGES RELATED TO THE AVOIDANCE OF A CO INTERMEDIATE, AND NO OBJECTIVE EVIDENCE OF THE EXPECTATION OF THE SAME HAS BEEN PRESENTED

It is submitted the claimed combination of a formic acid fuel together with palladium nanoparticles achieves unexpected and unpredictable benefits over the prior art. As disclosed in the specification:

> (a palladium nanoparticle catalyst) has been discovered to be particularly advantageous when employed in the present formic acid fuel cells because it is believed the palladium nanoparticle catalyst promotes direct formic acid oxidation and prevents poisoning of the catalyst with carbon monoxide while providing increased current and voltage efficiency.

Para 37. Also:

> The results in Fig. 4 also imply that the formic acid oxidation at a palladium nanoparticle anode may have a very low activation energy. This low activation energy for oxidation of formic acid is evidence that formic acid oxidation at a palladium nanoparticle anode occurs via a direct mechanism that does not include formation of CO as an intermediate.

Para. 57. As explained in the specification and understood by those knowledgeable in the art, formation of a CO intermediate is undesirable for several reasons. These include that the CO intermediate is believed to poison the cathode and thereby reduce cell efficiency, and that CO is poisonous to humans and therefore presents hazards. Para. 41, 43.

The avoidance of a CO intermediate achieved by the claimed cell represents an unpredictable and unexpected benefit over prior art fuel cells that produced CO. This result is believed to occur at least partially as a result of the claimed combination of a formic acid fuel solution together with palladium nanoparticle catalyst. The '434 publication teaches the use of a methanol fuel solution, and therefore one knowledgeable in the technology involved would find no motivation or expectation of such an unpredictable result relating to formic acid fuel.

THE FUEL CELL OF CLAIM 1 ACHIEVES UNPREDICTABLE AND UNEXPECTED ADVANTAGES RELATED TO POWER DENSITY AND EFFICIENCY, AND NO OBJECTIVE EVIDENCE OF THE EXPECTATION OF THE SAME HAS BEEN PRESENTED

Further, the specification discloses that the claimed fuel cell using a formic acid fuel solution together with a palladium nanoparticle catalyst yields unexpected power density and voltage efficiency. "Direct formic acid fuel cells with a palladium nanoparticles catalyst outperformed the one with the PtRu anode catalyst by more than 237% in the maximum power density and outperforms the direct methanol fuel cell with a PtRu catalyst by more than 440%." Para. 52. This increased power and efficiency may be related to the Pd catalyst's tendency to avoid formation of a CO intermediate: "the higher open cell voltage and voltage efficiency are possible in part because palladium nanoparticles catalyst selectively employ the direct method of converting formic acid to water, carbon dioxide and electricity without the production of CO intermediate. This ... means less poisoning of the catalyst by CO and therefore better catalyst performance." Para. 66.

THERE CAN BE NO EXPECTATION OF SUCCESS OR MOTIVATION TO COMBINE A METHANOL FUEL SOLUTION OF THE '434 PUBLICATION WITH A FORMIC ACID FUEL SOLUTION SINCE METHANOL AND FORMIC ACID ARE KNOWN TO REACT DIFFERENTLY

Claim 1 and all claims dependent thereon require a formic acid fuel solution in combination with a palladium nanoparticle catalyst. The '434 publication, on the other hand, teaches methanol fuel solutions used with its palladium catalysts. One considering the '434 publication would not be led to the claimed combination since methanol and formic acid are known to react differently. This is made clear in the present application: "Palladium, however, is not a good anode catalyst for methanol oxidation." Para. 52. To allege that the claimed invention is obvious in view of the '434 publication therefore impermissibly views the reference through hindsight after considering the present invention.

NO REFERENCE HAS BEEN CITED WHICH COMBINES A FORMIC ACID FUEL SOLUTION WITH A PALLADIUM CATALYST

It is noted that no reference has been cited which discloses a fuel cell having a formic acid fuel solution in combination with a palladium catalyst. It is submitted that this is evidence of the non-obviousness of the claims, particularly in view of the maturity and number of references in the fuel cell arts. Indeed, it is noted that prior to the invention of the parent application (now patent) of the current application, fuel cells having particular concentration ranges (including those of some presently claimed embodiments) of formic acid were unknown, regardless of particular catalyst (see U.S. patent number 7,132,138 from which the current application claims priority).

C. SEVERAL DEPENDANT CLAIMS ARE ALLOWABLE ON AN INDEPENDENT BASIS

Claims 2-24 and 51 all stand rejected as obvious over the '434 publication, further in view of the '487 patent for claims 3-4. These claims all depend from claim 1 and are allowable for the same reasons as are that claim. Several of these claims are allowable on an independent basis as well.

THE EMBODIMENT OF CLAIM 2 ACHIEVES UNEXPECTED RESULTS AND ITS LIMITATIONS ARE NOT SUGGESTED OR DISCLOSED BY THE CITED REFERENCES

Claim 2 requires that the fluid fuel comprises at least 3 M formic acid. The cited references fail to disclose or suggest this limitation. In fact, it is noted that the '434 publication fails to disclose *any* fuel solution concentration much less the claimed 3 M formic acid concentration. As discussed in the specification, the 3 M fuel concentration in combination with the claimed catalyst was discovered to offer an unexpectedly high power density (237% greater than the same fuel concentration with a Pt-Ru catalyst and 440% greater than a methanol fuel cell with a Pt-Ru catalyst). Para. 58. One considering the '434

publication (which teaches only methanol fuel solutions) would not be led to this concentration of formic acid fuel. These unexpected benefits are therefore evidence that the claimed combination of claim 2 is not obvious and that the claim is allowable.

THE '434 PUBLICATION TEACHES A DIFFERENT APPROACH TO REDUCING CROSSOVER, AND ONE CONSIDERING IT WOULD NOT BE LED TO THE EMBODIMENT OF CLAIM 8.

Claim 8 recites that the ion exchange membrane is substantially impermeable to the fuel. The '434 publication fails to teach or suggest this, and in fact teaches away from this. The '434 publication teaches that methanol is known to penetrate (or cross over) the ion exchange membrane: "...significant amounts of methanol can cross-over the PEM with a resulting reduction in performance and efficiency of the fuel cell." Para. 87.

To avoid crossover, the '434 publication takes a different approach than the embodiment of claim 8. The '434 publication teaches reducing or eliminating contact of the methanol fuel with the membrane is desirable to reduce crossover. The '434 publication teaches accomplishing this through use of engineered layers in the anode layer that reduce penetration of the methanol to the electrolyte and that direct fluid flow through the anode layers in a direction parallel to the electrolyte layer. Paras. 87-88.

Because it teaches its membrane is permeable to its fuel solution and because it teaches a different approach to reducing crossover, one considering the '434 publication would not be led to the structure of claim 8. To hold this claim obvious over the '434 publication impermissibly views that reference through hindsight after considering the present invention and is improper.

CLAIMS 16-20 RECITE FUEL SOLUTION CONCENTRATIONS THAT ACHIEVE UNEXPECTED RESULTS AND THAT ARE NOT DISCLOSED OR SUGGESTED BY THE CITED REFERENCES

Claims 16-20 recite fuel solution limitations not disclosed or suggested by the '434 publication. Claim 16 requires that the fuel comprise between about 21% and about 100% by weight of formic acid. Claim 17 recites that the fuel comprise between about 25%

and about 65% by weight formic acid. Claim 18 recites that the fuel comprise at least about 30% by weight water. Claim 20 requires that the oxidant comprise air in the formic acid at a concentration between about 20% and about 40% by weight.

These limitations are not disclosed or suggested by the '434 publication. As noted above the '434 publication not only fails to teach any formic acid fuel, but further fails to teach any concentrations for the methanol fuel solutions it discloses. Prior to developments by the present inventors that led to the present invention (as embodied in U.S. patent number 7,132,188 from which the current application claims priority on), these formic acid fuel cell concentrations were completely unknown, regardless of any particular catalyst.

It is further submitted that the various concentration ranges recited by these dependent claims in combination with the claimed catalyst achieve important and unexpected benefits over the prior art. This is believed to at least partially result from the correlation between formic acid concentration and electrolyte membrane crossover in fuel cells of the invention: "the concentration dependent crossover of formic acid may be one of (the) crucial factors that affects the output of fuel cells" paragraph 63. This is further evidence that claims 16-20 are not obvious over the '434 publication.

CONCLUSION

In conclusion, it is submitted that the claims in their present form are allowable over the cited prior art. Claim 1 is allowable for at least the following reasons:

- The cited references fail to teach a formic acid fuel used with a Pd nanoparticle catalyst
- The cited references fail to offer any teaching, suggestion or motivation to combine a Pd nanoparticle catalyst with a formic acid fuel
- The claimed combination achieves unexpected results

Several dependant claims are allowable for other reasons as well, including:

- Claim 2 requires at least 3 M formic acid that is not disclosed in the prior art. Further, this fuel in combination with the claimed catalyst was discovered to offer an unexpectedly high power density (237% greater than the same fuel concentration with a Pt-Ru catalyst and 440% greater than a methanol fuel cell with a Pt-Ru catalyst).

- Claim 8 recites that the ion exchange membrane is substantially impermeable to the fuel, and the '434 publication teaches away from this.
- Claims 16-20 teach particular fuel concentrations that are not taught or suggested in the prior art and that lead to unexpected results.

Timely examination and allowance are respectfully requested.

Respectfully submitted,

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